Cold Crucible Induction Melting

Cold crucible induction melting has the potential to significantly simplify and reduce the cost for stabilizing waste around the world. Future applications include processing high-purity and corrosive products – like alumina, zirconia, ruby-glasses and custom-design specialty glasses – at temperatures greater than 1,300°C in a wear-free melter vessel.

The Cold Crucible Induction Melter is shown with its protective barrier and external system connections, including its offgas system.

INL Capabilities

INL has designed and built a Cold Crucible Induction Melter (CCIM) prototype in an integrated test bed also capable of testing an array of offgas treatment technologies. The 60kW melter can operate over a range of frequencies from 100KHz to 4MHz. The system is unique in North America and is capable of testing solid, liquid, and slurry feeds with continuous processing.

Theory of Operation

This melter inductively heats an electrically conductive susceptor (graphite in this case) to start a melt. As melting propagates through the feed, the susceptor is consumed. Water-cooling of the crucible causes a thin frozen layer, or shell, to form inside the melter's walls. Thus the CCIM can achieve melt temperatures up to at least 3000°C while maintaining the melt in a solid containment shell of the feed composition. The shell, or "skull," isolates the melt from the crucible that is maintained at ambient conditions. These conditions eliminate the need for glass-contact refractory and concern over material corrosion and temperature limitations.

Technology Advantages

No Refractories— With no refractory, melts covering a range of basicity and redox conditions can be processed without concern over melter wear or life expectancy.

No Electrodes— With no metallic or oxide electrodes, routine operation with melt temperatures in excess of 2000°C can be maintained.

Water Cooled— The water-cooled crucible is fabricated out of standard materials and is protected from corrosion by the cold shell.

Self-Cleaning— By maintaining the crucible at a much lower temperature than the melt itself, the molten material does not bond to the melter. After cooling, the residuals can be readily removed from the melter.

High Purity— Very high purity melts are attainable with the melt contained in its shell (of the same composition) and no refractories or electrodes present to corrode and introduce contaminants at high process temperatures. This also means that the melter can be readily cycled daily from one feed to another without thermal damage or loss of composition control.

High-Level Waste Applications

Within the Department of Energy and similar worldwide programs, stabilization of highly radioactive waste in glass is recognized as an

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extremely durable and long term waste form.

Problematic Wastes— Many waste compositions – containing chromium, aluminum, zirconium, sulfate, or phosphate – are a challenge to incorporate in glass. These require significant additives to process in conventional joule-heated melters and may increase the glass volume and create possible process schedule delays and cost penalties.

Flexible Operation— The CCIM allows processing at much higher temperatures and provides the needed flexibility for glass chemists to design matrices to safely and effectively incorporate much more waste. Higher processing temperatures also increase processing rates and allow for greater throughput and a smaller footprint.

Commercial Applications

High purity and special run materials do not require the throughput needed for plate or bottle glass. Specialty materials do require precise process control, quality assurance and flexibility (all possible with the CCIM), to process small quantities of custom materials.

Purity with Durability— The melter design can process high purity or high temperature materials without crucible damage. In most applications its design eliminates the need for platinum or disposable oxide crucibles.

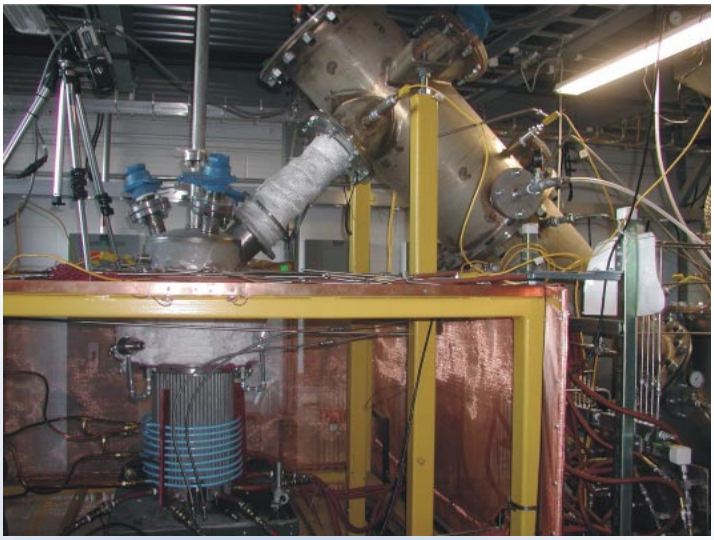
Operating Flexibility— By maintaining the crucible at near ambient conditions, the melting process can be started and stopped without thermal cycling damage. This not only allows short duration runs, but also allows rapid change to different products without losing compositional control.

INL Partnering

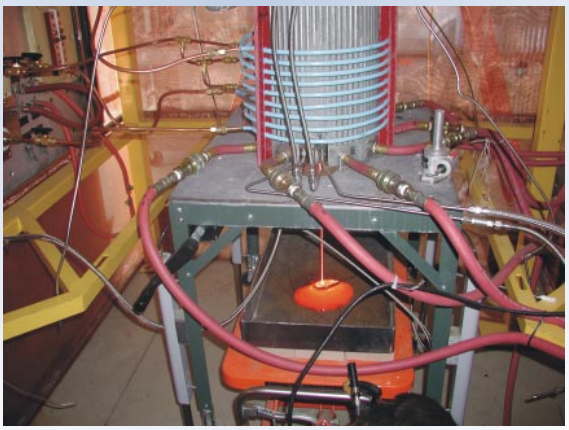
INL's team is actively collaborating with colleagues at the Khlopin Radium and Electrotechnical Institutes in St. Petersburg, and at Radon, as well, in Moscow, Russia. This collaborative effort brings together a substantial capability in electro-thermal modeling, electrical and mechanical engineering and manufacturing. In addition to R&D for the Department of Energy complex, INL seeks opportunities to resolve other technical challenges for taxpayers and industry.

Invitation to Tour Test Bed

We invite you to visit INL's melter and see the integrated thermal test bed facilities that incorporate fluidized-bed processing capabilities and advanced offgas treatment.



View of the melter environment with its specially designed offgas system.



Demonstration simulating the potential for encapsulating wastes in a glass matrix.